Astronomy UN2002 (Introduction to Astrophysics II) Spring 2020
Due Mon. May 4 Prof. J. Halpern

Homework #11

1. Estimate the temperature and age of the Universe at "freeze-out," when the neutron-to-proton ratio temporarily became fixed at 1/6.

2. Given the result of Big Bang nucleosynthesis models that derived $\Omega_{b,0} = 0.044$:

   (a) Estimate the density *of baryons*, in kg m^{-3}, at the time of cosmological nucleosynthesis, $t \approx 200$ s, and compare it to the mass-density of radiation at that time. Compare both densities to the density at the center of the Sun, which you can find, e.g., in Figure 15.7 of the text.

   (b) Why could helium be produced in the first 5 minutes of the Universe, while it takes a star like the Sun billions of years to make helium?

3. Critique the dialog about cosmology in the 1977 film *Annie Hall* (link below, and on the course web page for April 15). In terms of our knowledge of cosmology then and now, which lines in the script were correct, and which were incorrect or inaccurate?

   https://www.youtube.com/watch?reload=9&v=5U1-OmAICpU